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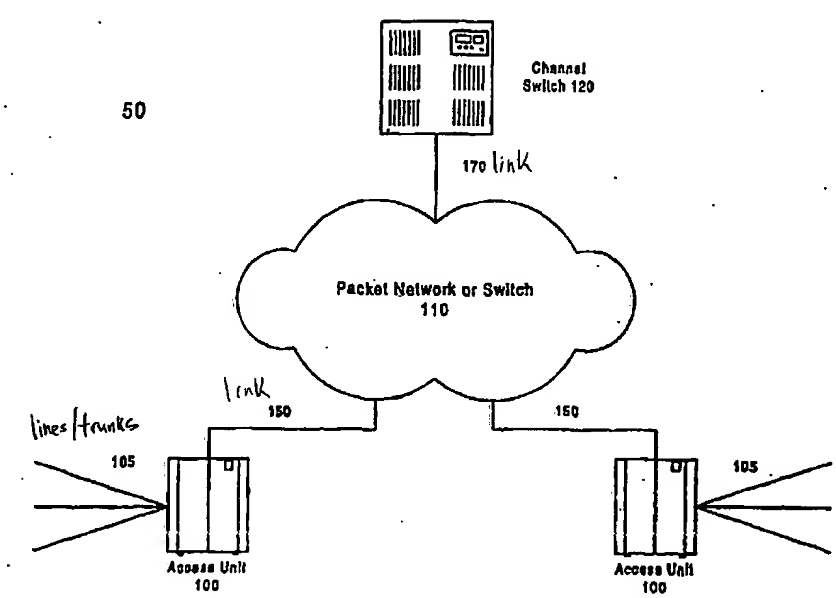

(57) Abstract

A telecommunications network provides efficient switching for voice-over-data lines by access units coupled to the sources and destinations of telephone calls using virtual channels created in a packet switch to connect to a channel switch that converts incoming packets into the outgoing packets and causes the packet switch to route the outgoing packets to the proper access units.

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Architecture for Distribution of Voice Over ATM Networks

Description

Technical Field

The present invention relates generally to telecommunications systems and, more particularly, to a telecommunications system for carrying voice over packet-switched networks.

Asynchronous Transfer Mode (ATM) represents a standard for transmitting voice, data, and video signals at very high speeds (25 Megabits/second and higher). The increasing deployment of ATM networks, particularly on customer premises, has created a need to provide high quality transport, switching, and call processing of voice communications over a packet network with minimal delay. The delay must not exceed that currently permitted for existing Private Branch Exchanges (PBXs), and the voice quality must be at least as good as such systems to allow a seamless upgrade from present day centralized PBXs to ATM distributed voice services.

Conventional network architectures for carrying voice over ATM have focused on large centralized or distributed voice switching networks. Two such architectures are described in Ron A. Spanke and J. Mark Adrian, "ATM Composite Cell Switching For DSO Digital Switches," XV International Switching Symposium, pp. 268-272, 1995, and Roy Mauger and Simon Brueckheimer, "The Role of ATM in 64kb/s Switching and Transmission Networks," XV International Switching Symposium 1995, pp. 87-91. These architectures, however, are designed for large switching systems, such as for central office applications. They suffer when used for distributed voice-over-ATM systems within a customer's premises or campus environment due to blocking limitations, bandwidth inefficiency, and trunking effects.

The main components of such systems are access and switching units and the ATM network or switch. The access and switching units provide two functions: (1) switching voice calls from one channel or trunk to another channel or trunk attached to the same unit, and (2) multiplexing voice calls from a channel or trunk into ATM cells to be sent through the ATM network to a channel or trunk attached to a destination access and switching unit. A

channel includes any type of voice or communications channel, for example, the H. 320 video at 384 Kbits/sec.

The destination access and switching unit demultiplexes the voice calls onto the appropriate channel or trunk. A channel can be, for example, a DSO single voice channel, which is a 64 kilobit/second, PCM-encoded digital signal converted from an analog voice signal, and a trunk can be, for example, a T1 or E1 facility, which carries multiple DSOs.

An ATM virtual channel is a packet-switched connection between two points using a logical connection consisting of a set of header and port switching translations at every node through which the ATM cell passes. The voice capacity of an ATM virtual channel depends on the number of DSO voice channels it can carry, which, in turn, depends on the format used to multiplex voice calls into ATM cells.

The key features of an ATM network carrying voice traffic include: (1) voice channel (DSO) switching capacity, (2) ATM bandwidth efficiency, and (3) equipment cost and utilization. To design such a network, engineers use simplifying assumptions to ensure the network meets the needs for all conditions. For one assumption, all ATM virtual channels in the network have the same DSO voice channel capacity, all access links carrying virtual channels to the ATM network have the same capacity, and each access link can support the same number of virtual channels.

The worst case routing scenario uses the maximum number of virtual channels while carrying the lowest number of voice channels. With N access and switching units, the worst case scenario occurs when only one channel from an access and switching unit is destined for each of the (N - 2) other access and switching units, and all the remaining channels are destined for the (N - 1)th access and switching unit. Other routing scenarios can use as many virtual channels as this scenario, but none uses more. This scenario requires that the maximum number of channels, n, that can be accommodated without blocking a single access and switching unit under the worst routing scenario is:

$$n = L_{max} - (T_{min} - 1)(N - 2), \qquad (1)$$

where L_{max} is the maximum number of channels that can be carried by the trunking scheme on a given size link and T_{min} is the minimum number of channels carried by a trunking scheme between an access and switching unit and the ATM network.

The maximum network capacity is found by multiplying n (from equation (1)) times the number of access and switching units (N), and optimizing. Thus, the number of access and switching units in the largest capacity system, N_{large}, is:

$$N_{large} = 1 + \frac{L_{max}}{2(T_{min} - 1)} \qquad (2)$$

The number of DSO voice channels supported on an access link in this largest system, $_{large}$, is:

$$n_{large} = \frac{L_{max}}{2} + (T_{min} - 1), \qquad (3)$$

Equations (1) -(3) assume full mesh connectivity of access and switching units because any call connected to an access and switching unit may be destined for any other access and switching unit.

Equation (1) forces system designers to contend with the fact that the number of voice channels supported at an access and switching unit decreases as the number of access and switching units, N, increases. This causes designers to overengineer access and switching units, which in turn increases equipment and system costs.

As a concrete example, each access link from the access and switching unit to the ATM network could be an STS-3c with L_{max}=2112 and T_{min} =48. Using these values in equation (2) yields twenty-three access and switching units in the largest possible system. Each access link can support

1103 DSO voice channels, so the total system capacity is 25,369 DSO voice channels. A typical PBX system in a distributed environment, on the other hand, may want only 200 channels per distributed location, so a typical twenty-three node network would only require a total system capacity of 4600 DSO voice channels.

Therefore, the conventional architecture does not provide an optimal design for replacing PBX systems with voice-over-ATM networks in a distributed environment. The results cause significant over engineering of access links to support the required connectivity. Therefore, few distributed PBX systems can be created with the conventional voice-over-ATM architecture.

Disclosure of the Invention

There is a need for a packet switching network architecture to carry voice traffic, such as a voice-over-ATM network, to replace PBX systems with many distributed locations. There is a corresponding need to optimize bandwidth efficiency as well as equipment cost and utilization in a packet switching network carrying voice traffic, such as a voice-over-ATM network, to avoid over engineering the network to provide the required connectivity. There is also a need to provide for tradeoffs between bandwidth efficiency and delay due to packetization of voice calls.

Additional desires and goals will be set forth in part in the following description, and in part will be obvious from the description, or may be learned by practice of the invention. The desires and goals of the invention will be realized and attained by the elements and combinations in the appended claims.

To achieve these goals and in accordance with the purpose of the invention, as embodied and broadly described herein, a telecommunications network according to the present invention for routing telephone calls from sources to destinations includes (1) a multiple of access unit means for (a) converting incoming calls to incoming packets, (b) constructing outgoing calls from outgoing packets, and (c) routing constructed calls to their destinations;

(2) a packet switching means having ports for (a) receiving the incoming packets from the access unit means and (b) providing the outgoing packets to the access unit means corresponding to the destinations of the outgoing packets; and (3) a channel switching means, coupled to the packet switching means, for (a) converting the incoming packets to outgoing packets and (b) routing the outgoing packets to the ports of the packet switching means that couple to the destination access unit means.

A method according to this invention for configuring a telecommunications network having access units and channel switching units coupled to a packet switching means includes the steps of determining the required number of channel switching units, N, from the size of the channel switching units, determining the maximum number of channels for each channel switching unit, coupling the access units and the channel switching units to a packet switch, and assigning each access unit to one of the channel switching units.

A method of packing DSO voice channels into an ATM cell includes the steps of determining a number, M, of DSO channels, where M is a divisor of 48; placing 48/M samples from each DSO voice channel into the cell in a contiguous field; and setting an indication in the header of the cell to indicate the packing.

Both the foregoing general description and the following detailed description are exemplary and explanatory only and do not restrict the claimed invention.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the invention and together with the description serve to explain the principles of the invention. In the drawings:

Figure 1 shows a network consistent with the present invention;

Figure 2 shows another network consistent with this invention;

Figure 3 shows another network consistent with this invention; and

Figure 4 shows examples of a multiplexing format consistent with this invention.

Detailed Description of the Preferred Embodiment

Reference will now be made in detail to the preferred implementations of the invention, examples of which are illustrated in the accompanying drawings. Wherever appropriate, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

A. Network Architecture

Figure 1 shows a preferred embodiment of a network 50 consistent with this invention. Network 50 includes several access units 100, a packet network or switch 110, and a channel switch 120. Unlike conventional systems, the access units 100 in network 50 are separate from channel switch 120 and include only the electronics and control from conventional access and switching units needed to convert incoming calls to packets, reconstruct outgoing calls from packets, and route those calls to their destinations. Each access unit 100 is coupled to packet switch 110.

Voice telephone calls from sources such as handsets or PBXs arrive at access unit 100 via lines or trunks 105. Line 105 may be a channel carrying a single DSO, and trunk 105 may be a T1 or E1 facility.

Access unit 100, which can be part of a modified PBX switch, such as Nortel's Meridian™ switch, adapted to communicate with an ATM network, receives and converts telephone calls into ATM cells. According to the ATM standard, each cell contains fifty-three bytes: forty-eight bytes of payload information and five bytes of header information. Access unit 100 packs the telephone call data into the 48-byte payload field using conventional methods for multiplexing voice DSOs into AIM virtual channels, such as T1/E1 circuit emulation service (CES) based on ATM Adaptation Layer 1 (AAL1), or n x 64 kbps multiplexing based on the structured data transfer mode of AAL1. Another multiplexing format is discussed below in more detail.

Access unit 100 also receives outgoing ATM cells from packet switch 110 and determines the destination of the telephone call for each packet

based on packet header information. Access unit 100 then converts the packets to the carrier format for the line or trunk 105 corresponding to the destination of the telephone call.

As Figure 1 shows, packet switching means 110 exchanges packets with access unit 100 over links 150. For ATM cells, link 150 is an ATM 25.6 Mbps link or higher speed link, such as an STS-3c (155.52 Mbps).

Packet switch 110 can be either a single ATM switch, such as the Magellan Passport™ or Magellan Concorde™, or a network of interconnected ATM switches. Link 150 connects to packet switch 120 via a standard ATM interface corresponding to the bandwidth of link 150.

After receiving packets from access unit 100 over link 150, packet switch 110 sends the packets to channel switch 120 via link 170. For ATM cells, link 170 is a high speed ATM link such as an STS-3c (155.52 Mbps). Packet switch 110 creates ATM virtual channels between access unit 100 and channel switch 120 for incoming packets that connect to physical links 150 and 170.

Packet switch 110 also receives outgoing packets from channel switch 120 via link 170, and routes those packets via link 150 via virtual channels to the access unit 100 corresponding to the destination of the call. Virtual channels in switch 110 between channel switch 120 and unit 100 also route the outgoing packets from channel switch 120 to access unit 100.

Network 50 operates more efficiently than conventional voice-over-ATM architecture because the functionality provided by channel switch 120 has been removed from access units 110 and placed at a single point in the network instead of being distributed throughout the network. Access links 150 therefore do not need the excess bandwidth that the conventional architecture uses to accommodate the full mesh connectivity of channel switching capability. As a result, network 50 avoids the over engineering problem of the conventional architecture.

Furthermore, the number of access units 100 is not limited as in the conventional architecture. Therefore, network 50 can create a distributed PBX

architecture with many more distributed locations than can the conventional architecture.

Figure 2 shows network 55, a variation of network 50, in which channel switch 120 is a single channel switching unit 125. Channel switching unit 125 converts incoming packets received from packet switch 110 into outgoing packets. Although each incoming packet contains telephone call data from sources connected to a single access unit via lines or trunks 105, each outgoing packet contains telephone call data whose destinations connect to a single access unit 100. In a preferred embodiment, channel switching unit 125 converts incoming packets into outgoing packets by extracting telephone call data from packets and multiplexing the data into new packets that each contain data destined for the same access unit 100. This may be accomplished by a multiplexer and demultiplexer within channel switching unit 125. The multiplexing format used by switching unit 125 preferably corresponds to that used by access unit 100.

Figure 3 shows network 58, a variation of network 55, with several channel switching units 125. Each access unit 100, however, is assigned to only one channel switching unit 125. Network 58 operates similarly to network 55, in one of two conditions. For telephone calls between a source and destination whose access units 100 are assigned to the same channel switching unit 125, that channel switching unit 125 functions as in Figure 2. For telephone calls between a source and destination whose access units 100 are assigned to different channel switching units 125, channel switching units 125 must perform additional steps.

Specifically, packet switch 110 first creates a virtual channel between access unit 100 and the corresponding channel switching unit 125 to which it is assigned. Packet switch 110 then transports packets from access unit 100, over this virtual channel, to the corresponding channel switching unit 125 called, for purposes of simplification, the source channel switching unit 125.

When source channel switching unit 125 finds call data destined for an access unit 100 assigned to a different channel switching unit 125, called for

purposes of simplicity, the destination channel switching unit 125, source switch unit 125 multiplexes the call data into an intermediate packet and sends the intermediate packet to destination switching unit 125 over a virtual channel in packet switch 110.

Next, outgoing channel switching unit 125 extracts call data from the intermediate packets and forms outgoing packets. Switch 120 transports the outgoing packets to the destination access unit 100 through a virtual channel in packet switch 110.

B. Network Design

For design purposes, the capacity and bandwidth of network 58 in Figure 3 can be determined using the following assumptions: (1) all DSO voice channels on each access unit 100 are assigned to one channel switching unit 125 for worst case routing between channel switching units 125, and (2) each channel switching unit 125 will have the same number of DSO voice channels assigned to it. Under worst case assumptions, every DSO voice channel coming into a channel switching unit 125 will need to be sent to another channel switching unit 125, so that $I_{max}=D_{max}$, where I_{max} is the bandwidth dedicated on a link for communications between channel switching units 125, and D_{max} is the number of DSO voice channels assigned to each channel switching unit 125. The basic equation governing link bandwidth is:

$$B_{max}-I_{max}+D_{max}+(N-2)(T_{min}-1), \qquad (4)$$

where B_{max} is the total bandwidth of links 175 (measured in terms of numbers of channels) between packet switch 110 and channel switching units 125. The last term in equation (4) represents the wasted bandwidth due to worst case routing.

D_{max} and T_{ch}, the total number of DSO voice channels supported by the system, can be calculated as:

$$D_{max}=\frac{1}{2}[B_{max}-(N-2)T_{min}-1)], \qquad (5)$$

$$T_{ch}=\frac{N}{2}[B_{max}-(N-2)(T_{min}-1)], \qquad (6)$$

The number of channel switching units 125 in the largest system, N_{large}, is:

$$N_{large}-1+\frac{B_{max}}{2(T_{min}-1)}, \qquad (7)$$

To obtain a network design equation, one must solve equations (5) and (6) for N, which must be less than N_{large}, as follows:

$$N=\frac{(2T_{min}-2+B_{max})-\sqrt{(2T_{min}-2+B_{max})^2-8(T_{min}-1)T_{ch}}}{2(T_{min}-1)} \qquad (8)$$

The ATM bandwidth efficiency for the system under maximum load with worst case routing is therefore:

$$Efficiency=\frac{B_{max}-(N-2)(T_{min}-1)}{B_{max}} \qquad (9)$$

Equation (3) shows that for conventional networks, the number of access and switching units is limited by L_{max}, as well as the bandwidth of each access link between the access and switching units and the ATM switch. Therefore, whenever an access and switching unit is added to the network, more bandwidth is required on each of the access links already in place.

Equation (7), however, shows that for networks designed according to this invention, the total number of switching units is limited by B_{max}, as well as the total bandwidth of links 175 between channel switches 125 and packet switch 110. Additional access units can be added to the network as long as the number of channels assigned to the switching units 125 has not exceeded D_{max}. Therefore, in network 55, the number of access units 100, n, is not

limited by the available bandwidth on links 150 between access units 100 and packet switch 110. On the other hand, the number of access and switching units in the conventional architecture is limited by the bandwidth available between the access and switching units and the packet switch.

The following example demonstrates the limiting effect of the conventional network architecture. Using the architecture of network 58 in Figure 3, a network with four channel switching units 125 and sixty access units 100 could be configured such that each access unit 100 used an average of 200 DSO voice channels. If each channel switching unit 125 is connected to the packet switch 110 via three STS-3c links, B_{max}, the bandwidth of each link 175, in terms of DSO channels, will be approximately 6336. According to equation (6), where T_{min} is 48, the total number of DSO channels supported by the network will be 12,484. Configuring with a network sixty access and switching units using the conventional architecture would force L_{max} to be greater than 5000, and the access link between each access and switching unit and the packet switch to include at least four STS-3cs, at over 600 Mbps. Such a network would be exorbitantly expensive and extremely over engineered.

C. Multiplexing Formats

As explained above, the networks in Figures 1 through 3 can be used with conventional multiplexing. Another multiplexing format, however, provides tradeoffs between bandwidth efficiency and cell fill delay. Figure 4 shows examples of this multiplex format along with an example of "single call per channel full cell fill," where the entire ATM cell is filled with 48 samples from one DSO channel, resulting in a cell fill delay of 6ms.

The multiplex formats accommodate data from *M*DSOs, where *M* is a divisor of 48. Each DSO contributes 48/Mbytes to a cell, and the position of those bytes is fixed within the cell for the duration of the DSO connection. Thus, all 48 bytes of the ATM cell payload are used.

The ATM user-to-user bit in the ATM cell header is turned on and off with each successive cell. This can be used as a 1-bit sequence number and for frame alignment.

The following table shows the cell fill delay and the ATM bandwidth used by each format.

TABLE I

Number of DSO's per Cell (N)	Number of bytes from each DSO	ATM bandwidth per VC	Delay in mSec
1	48	70,667	6
2	24	141,333	3
3	16	212,000	2
4	12	282,667	1.5
6	8	424,000	1
8	6	565,333	0.75
12	4	848,000	0.5
16	3	1,130,667	0.375
24	2	1,696,000	0.25
48	1	3,392,000	0.125

The choice of multiplexing format would be indicated via the management system or in the signaling messages used to set up the ATM virtual channel. Information elements in the signaling messages indicate the AAL layer being used.

A family of multiplex formats allows trade-offs between cell fill delay and system efficiency. Fewer DSOs in a format (N, Table I), means a smaller *Tmin*. *Tmin* shows up in the efficiency equation (9) and in capacity equations (5)-(7). If the total delay becomes too large, echo cancelers may be needed, adding expense and complexity. Therefore, in planning a system, the cell fill delay of the VoA (2) format is an important parameter m the overall delay

budget and this family of VoA formats allows one to trade off efficiency for cell fill delay.

D. Conclusion

It will be apparent to those skilled in the art that various modifications and variations can be made in the network and methods of the present invention without departing from the scope or spirit of the invention. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention. The specification and examples are only exemplary. The true scope and spirit of the invention is indicated by the following claims.

Claims

1. A telecommunications network for routing telephone calls from sources to destinations comprising:

a plurality of access unit means, coupled to the sources and destinations, for converting incoming calls from the sources to incoming packets, for reconstructing outgoing calls from outgoing packets, and for routing to the destinations the reconstructed outgoing calls, the access unit means acting as source access unit means when converting incoming calls and as destination access unit means when routing outgoing calls to the destinations;

packet switching means, coupled to the plurality of access unit means through input and output ports, for routing the incoming packets from the source access unit means through the input ports to a channel switching port, and for routing the outgoing packets from the channel switching port to the output ports coupled to the destination access unit means corresponding with the destinations of the outgoing packets; and

channel switching means, coupled to the packet switching means through the channel switching port, for converting the incoming packets into the outgoing packets and for causing the packet switching means to route the outgoing packets to the ones of the output ports of the packet switching means that couple to the destination access unit means corresponding to the destinations of the outgoing packets.

2. The telecommunications network of claim 1, wherein the channel switching means includes a single channel switching unit.

3. The telecommunications network of claim 1, wherein the channel switching means includes a plurality of separate channel switching units; and

wherein each of the access unit means is assigned to one of the channel switching units.

4. The telecommunications network of claim 3, wherein the packet switching means includes a separate channel switch port for each channel switching unit; and

wherein each of the channel switching units includes

means for converting incoming packets from the assigned access unit means to outgoing packets;

means for determining whether the destinations of each of the outgoing packets correspond to the ones of the access unit means assigned to that channel switching unit;

first means for causing, if the destinations of the outgoing packets correspond to the ones of the access unit means assigned to that channel switching unit, the packet switching means to route the outgoing packets to the ports of the packet switching means that couple to the ones of the destination access unit means assigned to that channel switching unit; and

second means for causing, if the destinations of the outgoing packets do not correspond to the ones of the access unit means assigned to that channel switching unit, the packet switching means to route the outgoing packets to the ones of the channel switch ports that couple to the channel switching unit assigned to the destination access unit means for the outgoing packets.

5. The telecommunications network of claim 4, wherein each of the channel switching units includes

means for converting incoming packets to intermediate packets; and wherein the second means includes

means for routing the intermediate packets to the ports of the packet switching means that couple to a destination one of the channel switching units corresponding to the destination access unit,

means for converting the intermediate packets to the outgoing packets, and

means for routing the outgoing packets to the ports of the packet switching means that couple to the destination access unit.

6. The telecommunications network of claim 3, wherein the access unit means are coupled to the input and output ports of the packet switching means by access trunks carrying access channels;

wherein the switching units are coupled to the switch ports of the packet switching means by switch trunks carrying switch channels;

wherein the number of channel switching units is

$$N = \frac{(2T_{min} - 2 + B_{max}) - \sqrt{(2T_{min} - 2 + B_{max})^2 - 8(T_{min} - 1)T_{ch}}}{2(T_{min} - 1)} \qquad (8)$$

where T_{min} is the minimum number of access channels carried by one of the access trunks, B_{max} is the maximum number of switch channels carried by one of the switch trunks, and T_{ch} is the total number of access channels in the network; and

wherein the maximum number of access channels carried on access trunks corresponding to access unit means assigned to a channel switching unit is

$$D_{max} = \frac{1}{2}[B_{max} - (N-2)T_{min} - 1)],$$

7. The telecommunications network of claim 1, wherein the plurality of access unit means for converting incoming calls to incoming packets includes

means for converting incoming calls to Asynchronous Transfer Mode (ATM) cells.

8. The telecommunications network of claim 1, wherein the packet switching means includes an ATM switch.

9. The telecommunications network of claim 1, wherein the packet switching means includes an ATM network.

10. The telecommunications network of claim 1, wherein the access unit means includes

means for sampling the incoming calls, and

means for assembling the samples of the incoming calls to create the incoming packets; and

means for extracting from the outgoing packets samples of the outgoing calls.

11. The telecommunications network of claim 10, wherein the means for assembling the samples of the incoming calls includes a multiplexer; and

wherein the means for extracting the samples of the outgoing calls includes a demultiplexer.

12. The telecommunications network of claim 10, wherein the channel switching means includes

means for extracting the samples of the incoming calls from the incoming packets; and

means for creating the outgoing packets to contain only samples of the calls that have destinations coupled to the same access unit means.

13. The telecommunications network of claim 12, wherein the means for extracting the samples includes a demultiplexer; and

wherein the means for creating the outgoing packets includes a multiplexer.

14. A method for routing telephone calls in a telecommunications network from sources to destinations comprising the steps of:

converting at a plurality of access units incoming telephone calls from the sources to incoming packets;

receiving at ports of a packet switch the incoming packets from the access units;

routing the incoming packets to a channel switching unit;

converting the incoming packets received at the channel switching unit to outgoing packets;

routing the outgoing packets to the ports of the packet switch that couple to the appropriate access units;

converting the outgoing packets received at the plurality of access units to outgoing calls; and

routing the constructed outgoing calls to the destinations.

15. A method for configuring a telecommunications network having access units, channel switching units, and a packet switching means, comprising the steps of: determining a number of channel switching units, N, as:

$$N = \frac{(2T_{min}-2+B_{max}) - \sqrt{(2T_{min}-2 + B_{max})^2 - 8(T_{min}-1)T_{ch}}}{2(T_{min}-1)} \qquad (8)$$

where T_{min} is the minimum number of channels between each of the access units and the packet switching means, B_{max} is the channel capacity of the channel switching unit, and T_{ch} is the total number of channels in the network;

determining the maximum number of channels for each channel switching unit, D_{max}, as:

$$D_{max} = \frac{1}{2}[B_{max} - (N-2)T_{min} - 1],$$

coupling the access units and the channel switching units to a packet switching means; and

assigning each of the access units to one of the channel switching units such that none of the channel switching units has more that the maximum number of channels, D_{max}.

16. A method of packing DSO voice channels into an ATM cell comprising the steps of

determining a number, *M*, of DSO channels, where *M* is a divisor of 48;

placing 48/*M* samples from each DSO voice channel into the cell in a contiguous field; and

setting an indication into the header of the cell to indicate the packing.

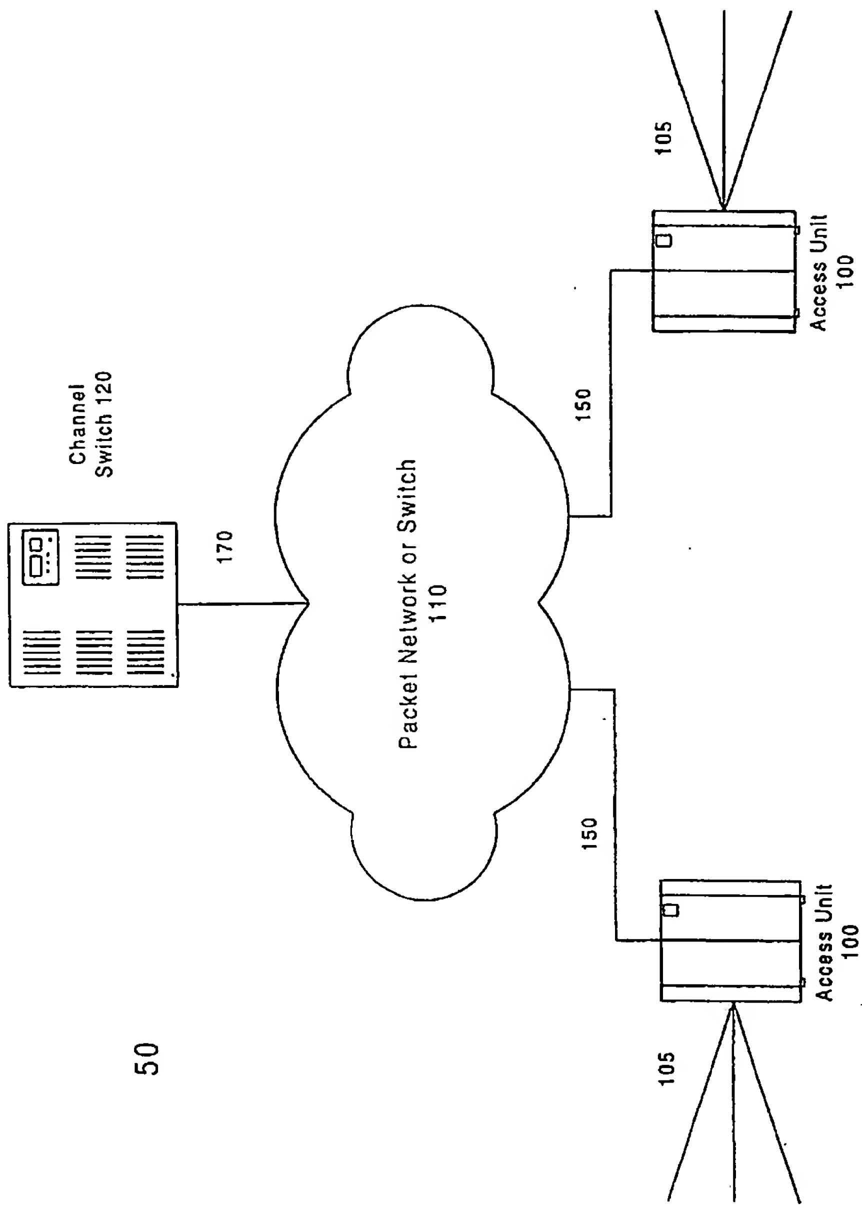
Channel Switch 120
170
Packet Network or Switch 110
150
150
Access Unit 100
Access Unit 100
105
105
50

Figure 1

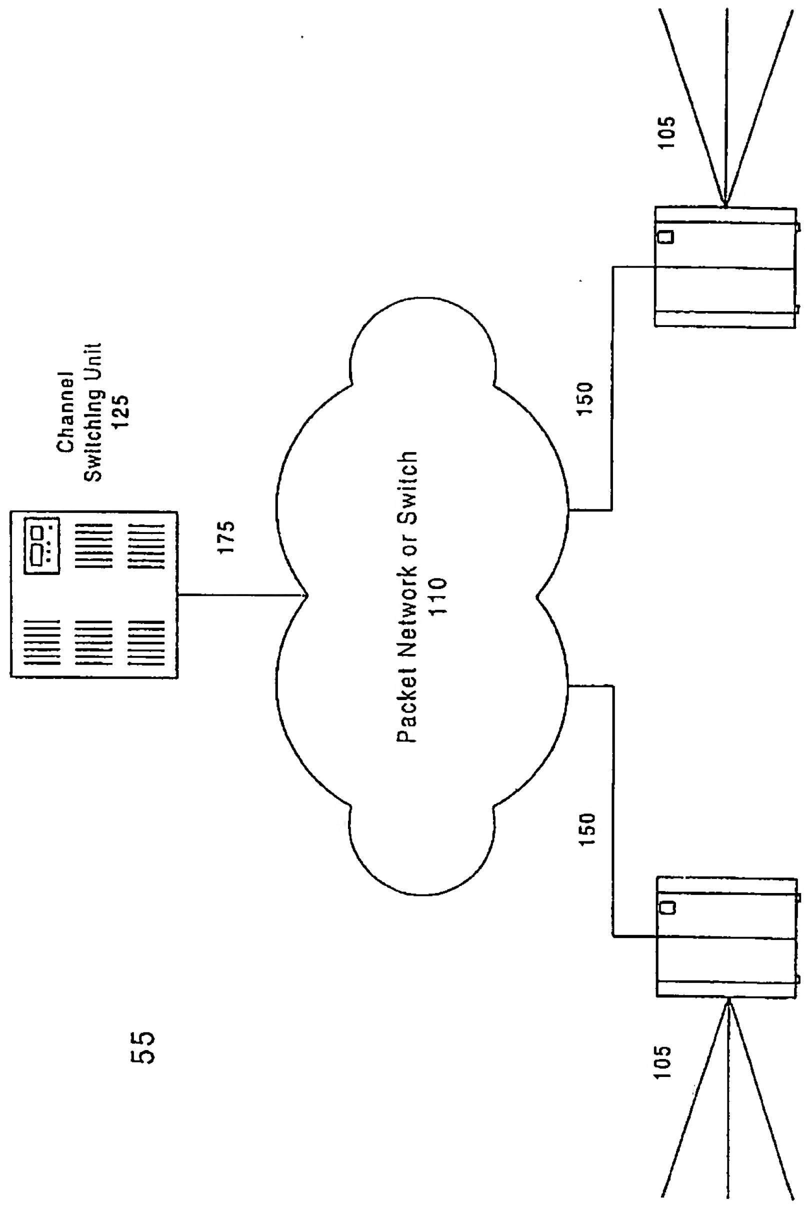
Channel
Switching Unit
125
175
Packet Network or Switch
110
150
150
Access Unit
100
Access Unit
100
105
105

Figure 2

55

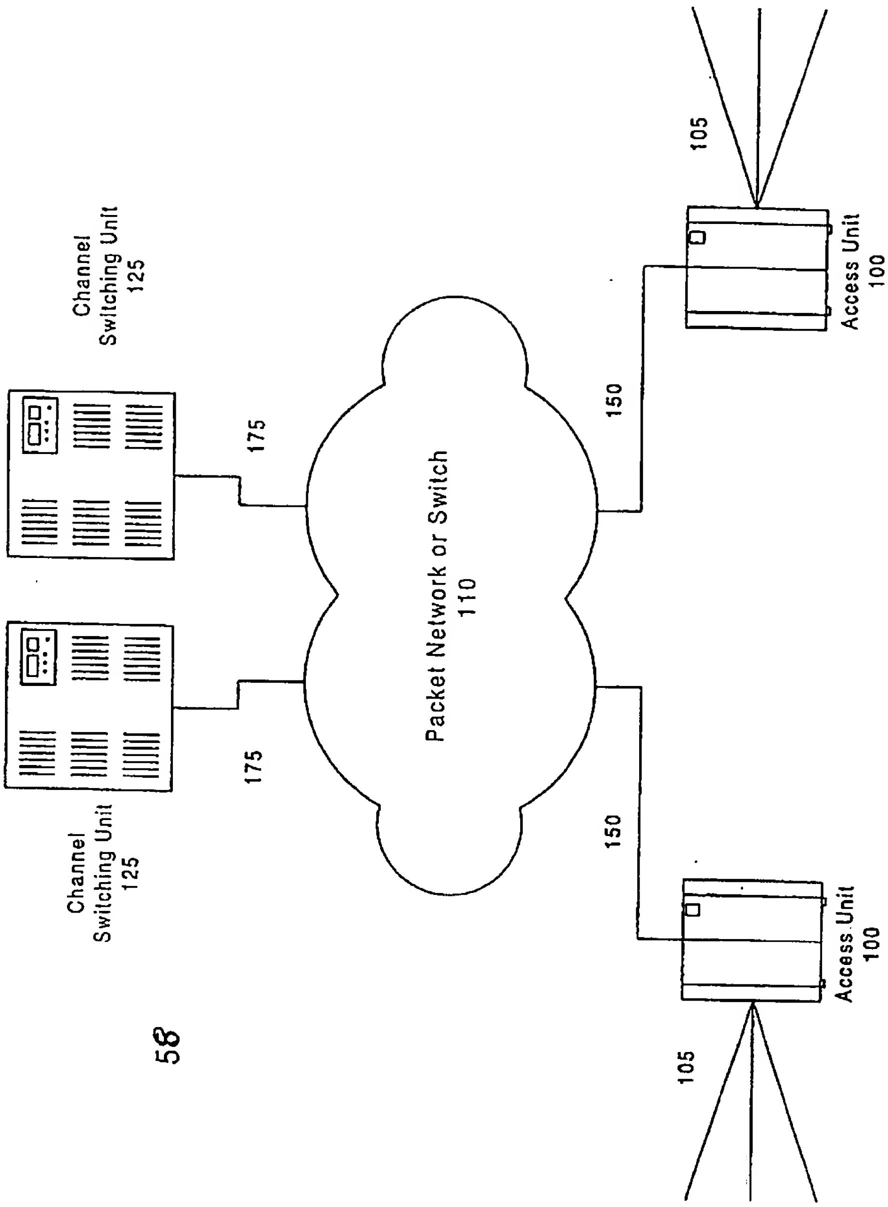
Channel
Switching Unit
125
Channel
Switching Unit
125
175
175
Packet Network or Switch
110
150
150
Access Unit
100
Access Unit
100
105
105

Figure 3

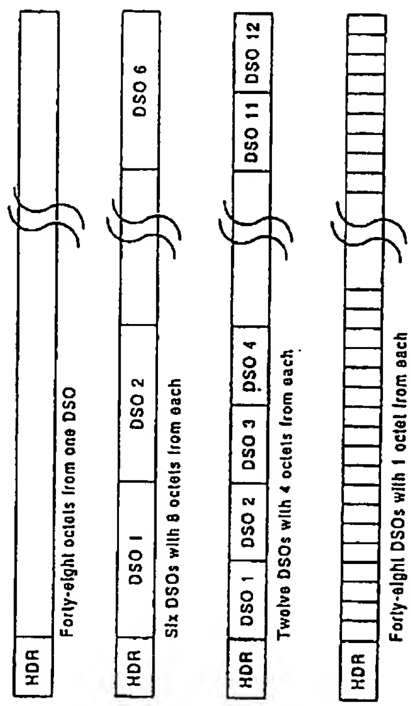
HDR
Forty-eight octets from one DSO
HDR
DSO 1
DSO 2
DSO 6
Six DSOs with 8 octets from each
HDR
DSO 1
DSO 2
DSO 3
DSO 4
DSO 11
DSO 12
Twelve DSOs with 4 octets from each
HDR
Forty-eight DSOs with 1 octet from each

Figure 4

INTERNATIONAL SEARCH REPORT

Int. ...ional Application No
PCT/IB 97/01407

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 17789 A (AT & T CORP) 29 June 1995 see page 11, line 32 - page 13, line 6; figures 2,3	1-3, 7-14,16
A	EP 0 225 714 A (BRITISH TELECOMM) 16 June 1987 see page 2, line 26 - line 32; figures 1,2 see page 3, line 29 - line 38 see line 1 - line 12 see page 4, line 31 - page 5, line 19	1-16

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 1998	02/03/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Veen, G

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 97/01407

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